George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

TD15-PLN-009
Baseline
December 13, 1999

Project Plan

For

Operations and Range Technology (ORT)

Spaceliner 100 Investment Area

ADVANCED SPACE TRANSPORTATION PROGRAM OFFICE (ASTP)

TD15

Operations and Range Technology Project Plan
Table of Contents

OPERATIONS AND RANGE TECHNOLOGY PROJECT PLAN

SIGNATURE PAGE

Prepared by:

Original Signed By — December 13, 1999

Warren Wiley — Date

Operations and Range Technology Project Manager (KSC)

Approved by:

Original Signed By — December 13, 1999

Garry Lyles — Date

ASTP Program Manager

LIST OF ACRONYMS

AFSS	Autonomous Flight Safety System
AIT	Assembly, Integration, and Testing
ASTP	Advanced Space Transportation Program
CDR	Critical Design Review
COTS	Commercial-Off-The-Shelf
DFRC	Dryden Flight Research Center
EAA	Enterprise Associate Administrator
ELV	Expendable Launch Vehicle
EM	Engineering Model
FDR	Final Design Review
FTE	Full Time Equivalent
FY	Fiscal Year
GFE	Government Furnished Equipment
GFP	Government Furnished Property
GPMC	Governing Program Management Council
IA	Independent Assessment
IDR	Initial Design Review
IVHM	Integrated Vehicle Health Management
JSC	Johnson Space Center
KSC	Kennedy Space Center
NOA	New Obligational Authority
LaRC	Langley Research Center
MagLev	Magnetic Levitated Launch Assist
MSFC	Marshall Space Flight Center
MOA	Memorandum of Agreement
NASA	National Aeronautics and Space Administration
NPD	NASA Program Directive
NPG	NASA Procedures and Guidelines
NRA	NASA Research Agreement
OAT	Office of Aero-Space Technology
PCA	Program Commitment Agreement
PCL	Passive Coherent Location
PDR	Preliminary Design Review
PMC	Program Management Council
PMS	Project Management System
RLV	Reusable Launch Vehicle

SRR	System Requirements Review
STD	Space Transportation Directorate
SSC	Stennis Space Center
STPO	Space Transportation Program Office
TCS	Temperature Control System
TDRSS	Tracking and Data Relay Satellite System
TPS	Thermal Protection System
TBD	To Be Determined

FOREWORD

This Project Plan describes the objectives, requirements, and planning for the Operations and Range Technology Project. This plan is consistent with the objectives, requirements, and plans documented in the ASTP Program Plan, ISO-STD-TBD. This plan has been prepared in accordance with the *NASA Program and Project Management Processes and Requirements,* NPG 7120.5A, and is consistent with the *NASA Strategic Management Handbook* and *NASA Program/Project Management*, NPD 7120.4A.

I. INTRODUCTION

The Aero-Space Technology Enterprise has 3 Pillars Goals and 10 Technology Objectives that aggressively address the critical aerospace needs of our Nation, most notably aviation safety, productivity, environmental stewardship, and cost effective access to space.

Space is the next frontier for our evolving transportation systems. As we move out from the planet, we open up new territory for exploration and development. Advancements in technology will enable us to do two things; extend our reach, enabling us to explore further into space, and allow commercial ventures to establish space operations and develop the commercial potential of space -- starting first with safe, reliable, low-cost access to space. Therefore, the Enterprise's efforts focus on developing technologies that enable new launch and in-space transportation systems with orders of magnitude improvement in safety, cost and reliability.

The current space launch systems of the Nation are too expensive due in part to the vehicle systems requiring a large workforce of highly skilled specialists to perform the test and assembly and checkout required. We have stretched, modified, and extended the old designs and old technologies to the point where we operate on thin margins. Within the next ten years, NASA will deliver the new technologies that will improve safety and reliability by a factor of 100 while reducing costs by a factor of 10.

The Operations and Range Technology Project is responsible for the development of key technologies to substantially reduce vehicle launch and processing operations costs and improve the systems safety and reliability. The focused technology research and development associated with the project include:

- Spaceport Range and Operations
- Automated Umbilicals
- MagLev Launch Assist
- Propellant Densification
- Containerized Payload Systems

This project is part of Advanced Space Transportation Program (ASTP) planning for the Spaceliner 100 Investment area.

II. OBJECTIVES

This project will develop advanced range, ground operations, launch assist, payload processing and flight operations technologies for future launch systems. Included are the operations tool development, and component, subsystems and systems demonstrations. Focused technology research and development in the following technologies will be carried out to advance the current state:

- Autonomous connections
- Rapid flow propellant loading
- Space based range
- Payload container development
- Advanced checkout and control systems
- Intelligent inspections systems
- Launch assist

III. CUSTOMER DEFINITION AND ADVOCACY

The Operations and Range Technology Project is aligned within MSFC's Advanced Space Program Office (ASTP) and NASA's Office of Aero-Space Technology (OAT) Enterprise, and supports the strategic goals of OAT's third pillar, Access to Space. Specific Access to Space Pillar goals are to achieve a ten-fold reduction in the cost of placing payloads into low-Earth orbit in the next decade and an additional ten-fold cost reduction in the decade beyond.

The primary customer of the Operations and Range Technology Project is the ASTP. Customer advocacy will be achieved by a number of approaches including instituting cooperative arrangements with government agencies and industry partners who have synergistic goals. These agreements will provide for the timely release of data that may be beneficial to current and future launch vehicle development programs. The Operations and Range Technology Project will conduct periodic technology exhibitions to highlight ongoing technology efforts. Customer participation in establishment, review, and approval of requirements and in design reviews will be encouraged.

IV. PROJECT AUTHORITY

The *NASA Strategic Plan* and the *NASA Strategic Management Handbook* assign to MSFC the Lead Center responsibility for Space Transportation Systems development. This assignment includes Lead Center responsibility for the ASTP Program of which the Operations and Range Technology Project is a part, although the Kennedy Space Center (KSC) is the Lead Center for this project. The KSC Future Vehicles and Advanced Programs Office (MM-B) is responsible for project implementation and management. The Operations and Range Technology Project has direct

commitments with MSFC and KSC. The KSC GPMC is responsible for oversight of the Operations and Range Technology Project.

V. MANAGEMENT

A. Organization and Responsibilities

1. NASA Headquarters

NASA's Office of Aero-Space Technology (OAT) Enterprise is responsible for the Operations and Range Technology Project.

2. Field Centers

The field centers involved in the Operations and Range Technology Project include: Marshall Space Flight Center and Kennedy Space Center. The involvement of each center is described below:

a. George C. Marshall Space Flight Center (MSFC)

The project is managed under the MSFC Space Transportation Directorate's (STD) ASTP Program Office.

b. Kennedy Space Center (KSC)

The Operations and Range Technology Project will be managed within the organizational structures and mechanisms of the Engineering Development Directorate (MM) at KSC.

B. Responsibilities

The tasks identified within this project will be managed out of the KSC Future Vehicles and Advanced Programs Office. Teams will be formed as required at the appropriate centers and industries to support the development of each task. Contractor support will be used with the permission of the Project Manager. The teams are empowered to develop the operations tools, and component, subsystems and systems demonstrations within the guidelines established in this project plan.

C. Special Boards and Committees

Not Applicable

D. Management Support Systems

The Project Manager is assisted by the organizational structures and mechanisms of the Engineering Development Directorate (MM) at KSC, including the Project management Office, the Systems Development Office, and the Technology Development Office

E. Management Information Systems

The KSC Engineering Development Directorate Project Management System (PMS) will be used to track the technical and fiscal progress of each task within the project. All plans, reports, schedules, design documentation, etc., shall reside on the KSC PMS, and only those records contained on the KSC PMS will be considered official and current.

VI. TECHNICAL SUMMARY

The Operations and Range Technology Project is comprised of two sub-projects:

- Low Cost Range and Operations, which currently includes the Automated Umbilical Mating (OPS-005), the Passive Coherent Location (OPS-025), and the Autonomous Flight Safety (NRA 8-21) development tasks
- MagLev, which currently includes the Magnetic Levitated Launch Assist (OPS) development tasks

A. Project Requirements

1. Automated Umbilical Mating (OPS-005)

This project will develop a smart umbilical with reconnect capability based upon a recently completed SBIR project. This project will provide autonomous operations using vision systems, force feedback, leak detection, and state-of-the-art real-time control. The umbilical will provide the capability to connect, disconnect, and reconnect at any point during the launch countdown process.

2. Passive Coherent Location (OPS-025)

Passive Coherent Location (PCL) is a passive all-weather precision surveillance system used for tracking aircraft and missiles. PCL does not radiate any RF signal within the PCL boundaries - rather, it uses electromagnetic energy which is already in the environment from sources such as broadcast television, FM, and other high energy sources. Reflected energy from target object(s) is then received by the PCL system and analyzed in real-time to determine the target's track. The objective is to evaluate the real-time capability, tracking accuracy and resolution of the PCL system.

3. Autonomous Flight Safety (NRA 8-21)

Phase one of three phase effort will develop requirements, perform preliminary design, develop decision algorithms, and perform simulations of a GPS/INS-based Autonomous Flight Termination System. Phases II & III, will incorporate component level technologies into breadboard hardware, and conduct ground and flight demonstrations.

4. Magnetic Levitated Launch Assist (OPS)

Develop a reliable, inexpensive, and low operational launch assist for sending payloads into orbit using ground powered, magnetically suspended and propelled launch assist technologies. Develop magnetic levitation, and linear motor technologies to investigate:

- Scalability for the Spaceliner vehicle concepts.
- Stability and control over the operating range of the system.
- Energy storage and distribution concepts over the operating range.
- Integration and interaction between the thrust cradle and the vehicle.
- Development of a full-scale technology demonstrator.

B. System Requirements

The systems requirements are consistent with the mission objectives listed in Section II of this plan.

C. System Constraints

There are no identified system constraints.

VII. SCHEDULES

Milestones denoted by an asterisk and bold italic type are Level I milestones reported in Advanced Space Transportation and Vehicle Systems Technology Program Plans.

A. Low Cost Range and Operations

1. Passive Coherent Location

- ****2QFY00 - Passive Coherent Location Range Demonstration***

Output: Demonstration of PCL Real-time wideband vehicle tracking and post mission processing of narrowband capabilities. Post mission processing will combine the results of both into a single tracking solution. This will then be provided to the range for determination of accuracy with relation to existing C-Band radars.

Outcome: Evaluation of the PCL accuracy will allow for determination of the need to continue with phase II PCL X-34 Real Time Display development and demonstration. This activity is part of the demonstration of technologies required to dramatically lower the cost of access to space. AST Enterprise Goal #9 - Reduce the payload cost to low-earth orbit by an order of

magnitude, from $10,000 to $1000 per pound, within 10 years, and by an additional order of magnitude within 25 years.

- ***4QFY00 - Passive Coherent Location on X-34***

  Output: Demonstration of PCL Aerospace Vehicle real-time tracking and display capabilities during an X-34 flight at DFRC. The accuracy of this integrated capability will be evaluated against other official tracking devices as a post mission process.

  Outcome: Evaluation and analysis of the PCL accuracy and real-time performance will support the decision to recommend PCL as a viable range tracking and surveillance system. If accuracy is not sufficient a decision to continue technology development or evaluate other tracking systems will be assessed. This activity is part of the demonstration of technologies required to dramatically lower the cost of access to space. AST Enterprise Goal #9 - Reduce the payload cost to low-earth orbit by an order of magnitude, from $10,000 to $1000 per pound, within 10 years, and by an additional order of magnitude within 25 years.

2. Automated Umbilical Mating

- 1QFY02 - Delivery of Prototype and Final report

  Output: Delivery of a qualified automated mating umbilical and final assessment report to MSFC.

  Outcome: Development of a smart umbilical with a connect and re-connect capability with remote interface verification. This project will leverage off of an existing SBIR project and additional available hardware. This activity is part of the demonstration of technologies required to dramatically lower the cost of access to space. AST Enterprise Goal #9 - Reduce the payload cost to low-earth orbit by an order of magnitude, from $10,000 to $1000 per pound, within 10 years, and by an additional order of magnitude within 25 years.

3. Autonomous Flight Safety System

- 3QFY00 - Autonomous Flight Safety System (AFSS) Phase I algorithm development and simulation complete

  Output: Verification of flight termination decision logic algorithm designs using software simulations. Simulations will include injection of anomalous conditions and real-time display of flight conditions relative to safety limits. Analysis of 20 test cases will be performed to evaluate the decision logic performance under a variety of flight conditions.

Outcome: Validation of decision logic and simulators will aid in the development, test and verification of the Test Flight Article breadboard. Simulation will provide for regression test of hardware and software during the development phase. This activity is part of the demonstration of technologies required to dramatically lower the cost of access to space. AST Enterprise Goal #9 - Reduce the payload cost to low-earth orbit by an order of magnitude, from $10,000 to $1000 per pound, within 10 years, and by an additional order of magnitude within 25 years.

- 3QFY01 - Autonomous Flight Safety System (AFSS) Breadboard Demo

  Output: Test and evaluation of the Test Flight Article breadboard using the MSFC ground simulation facility. Validation that the breadboard is ready for integration into a jet aircraft for flight test and demonstration

  Outcome: Validation of the breadboard will allow for a aircraft and later X-34 flight demonstrations of the Autonomous Flight Safety System. Further development and certification of this design provides capabilities that can be utilized on the 2nd generation vehicles and further enhanced as technology is developed for the 3rd generation. This activity is part of the demonstration of technologies required to dramatically lower the cost of access to space. AST Enterprise Goal #9 - Reduce the payload cost to low-earth orbit by an order of magnitude, from $10,000 to $1000 per pound, within 10 years, and by an additional order of magnitude within 25 years.

- 4QFY01 - Secure Digital Command Receiver Decoder Engineering Model

  Output: Engineering Model (EM) hardware and software integration and test have been completed.

  Outcome: Unit is ready for RF performance and enviromental testing that will be performed during Secure Digital Command Receiver Decoder TDRSS Compatibility Test by 1st quarter FY02. This activity is part of the demonstration of technologies required to dramatically lower the cost of access to space. AST Enterprise Goal #9 - Reduce the payload cost to low-earth orbit by an order of magnitude, from $10,000 to $1000 per pound, within 10 years, and by an additional order of magnitude within 25 years.

B. MagLev Launch Assist Development

- ****4QFY01 - MagLev Test Track at KSC***

  Output: Installation and test of the 400-foot test track at KSC

Outcome: To develop a safe, reliable, inexpensive, and minimum operation launch assist for sending small payloads into orbit using ground powered magnetic suspension and propulsion technologies. This activity is part of the demonstration of technologies required to dramatically lower the cost of access to space. AST Enterprise Goal #9 - Reduce the payload cost to low-earth orbit by an order of magnitude, from $10,000 to $1000 per pound, within 10 years, and by an additional order of magnitude within 25 years.

VIII. RESOURCES

A. Funding Requirements (NOA in Millions)

FY99	FY00	FY01	FY02	FY03	TOTALS
0.529	2.541	0.643	TBD	TBD	3.713

B. Institutional Requirements (FTE)

FY99	FY00	FY01	FY02	FY03	TOTALS
2.4	10.6	4	TBD	TBD	17

IX. CONTROLS

The Operations and Range Technology Project controls start with the Program Commitment Agreement (PCA) for the ASTP Program. The PCA is interpreted at every level to meet the NASA commitment and reflected in the technical, schedule and cost requirements imposed on each of the projects.

A. NASA Headquarters

The Operations and Range Technology Project Plan establishes the top level technical, schedule, and cost controls placed on the program. A semi-annual review of this plan will be performed to accommodate the changing nature of advanced technology projects.

B. Marshall Space Flight Center

The ASTP Program Plan and this Project Plan outline the technical, schedule and cost commitments of the Operations and Range Technology Project.

C. Kennedy Space Center

Subordinate Project Plans for Automated Umbilical Mating, Passive Coherent Location, Autonomous Flight Safety, and Magnetic Levitated Launch Assist further outline the technical, schedule and cost commitments of the Operations and Range Technology Project.

D. Change Controls

Proposed changes to the Operations and Range Technology Project Plan shall be submitted to the ASTP Program Manager for approval. Impacts to cost, schedule, and technical performance shall be included.

E. Interface Controls

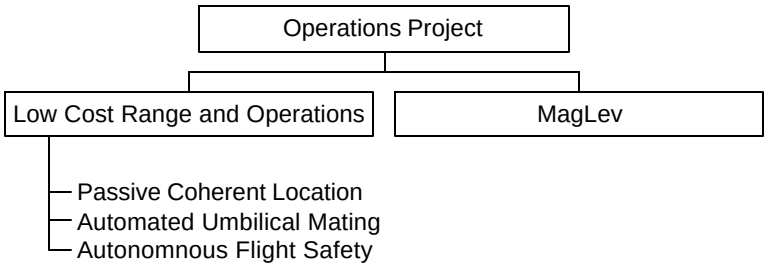
Interfaces and issues among the several STD programs are controlled by the Level II Board chaired by the STD Manager. Interfaces between the Operations and Range Technology project elements are controlled by the Operations and Range Technology Project Manager.

F. Project Plan Updates

The Operations and Range Technology Project Plan updates will occur as required to reflect project changes. Annually, the Operations and Range Technology Project Plan will be assessed by the KSC Future Vehicles and Advanced Programs Office to determine if updates are warranted. If appropriate, updates will be incorporated and will be coordinated with the ASTP Program Manager and KSC for concurrence.

X. IMPLEMENTATION APPROACH

KSC Operations and Range Technology Project WBS



XI. ACQUISITION SUMMARY

The Operations and Range Technology Project acquisition strategy is based on both NASA in-house and contracted activities. All of the planned individual contracts are currently anticipated to be

less than $10M. Because of the experimental nature of the existing contracts, NASA Research Announcements, Purchase Orders, and Support Agreements will be utilized to the greatest extent possible.

XII. PROGRAM/PROJECT DEPENDENCIES

Not Applicable

XIII. AGREEMENTS

A. Internal NASA Agreements

KSC has been assigned as the Lead Center for the Operations and Range Technology Project and is responsible for project implementation and management. The Operations and Range Technology Project will require significant coordination between MSFC and KSC. Coordination on specific technology development activities will be dictated by circumstances on an "as-needed" basis.

B. External Agreements

The Operations and Range Technology Project is expected to have external agreements through Contractors and other agencies. All external agreements will be determined by competition as part of the overall acquisition strategy.

XIV. PERFORMANCE ASSURANCE

Quality

If required, Operations and Range Technology flight hardware designed, developed and built in-house at MSFC will be in accordance with the MPG 144.1. In-house hardware may be built to dated drawings with the approval of the Lead Systems Engineer, as specified in the Operations and Range Configuration Control Plan. As built drawings will be submitted to the MSFC Configuration Control Process as specified in the Operations and Range Technology Configuration Control Plan. Operations and Range Technology flight hardware designed, developed, and built in-house at other Centers will be in accordance with the relevant Center policies and procedures.

Due to the limited scope of the Operations and Range Technology Project, flight hardware may be commercial off-the-shelf as long as it meets the requirements specified in the governing specification documents.

Operations and Range Technology flight hardware purchased from outside vendors is not required to be ISO 9000 compliant. Operations and Range Technology flight hardware purchased from outside vendors will be based on the specific requirements of NHB 5300.4(1C). Tailoring of these requirements will be reflected in the Operations and Range Technology Quality Plan and/or in the vendor purchase order/contract.

Operations and Range Technology flight hardware purchased from outside vendors must be delivered with a Certificate of Compliance (COC) and an acceptance data package as specified in the purchase order or contract.

XV. RISK MANAGEMENT

For flight hardware, an aggressive Risk Management Plan will be required to effectively manage the Operations and Range Technology Development project. This plan will document a continuous process that:

- identifies risks
- analyzes their impact and prioritizes them
- develops and carries out plans for risk mitigation, acceptance, or other action
- tracks risks and the implementation of mitigation plans
- supports informed, timely, and effective decisions to control risks and mitigation plans
- assures that risk information is communicated among all levels of the project

Risk management begins in the formulation phase with an initial risk identification and development of a Risk Management Plan and continues throughout the product's life cycle through the disposition and tracking of existing and new risks. A Risk Management Plan will be required if and when flight hardware is required.

XVI. ENVIRONMENTAL IMPACT

Environmental impact assessment(s) shall be developed as needed by the appropriate center(s) Environmental Engineering and Management Office(s).

XVII. SAFETY

The Operations and Range Technology Project will utilize existing KSC safety guidelines to provide for the early identification, analysis, reduction, and/or elimination of hazards that might cause the following:

- Loss of life or injury/illness to personnel
- Damage to or loss of equipment or property (including software)
- Unexpected or collateral damage as a result of tests
- Failure of mission
- Loss of system availability
- Damage to the environment

If required for specific tasks in the Operations and Range Technology Project, a safety plan that details such activities as system safety, reliability engineering, electronic and mechanical parts reliability, quality assurance for both flight hardware and software, surveillance of the development processes, "closed loop" problem failure reporting and resolution, environmental design and test requirements will be developed.

For flight operations, mission success criteria shall be defined to aid in early assessment of the impact of risk management trade-off decisions. The safety and mission success activity shall accomplish the following:

- Provide for formal assessment and documentation of each hazard, with risks identified, analyzed, planned, tracked, and controlled.
- Provide for a safety assessment and certification regarding readiness for flight or operations, explicitly noting any exceptions arising from safety issues and concerns.
- Utilize a quality management system governed by the ISO 9000 standard, appropriate surveillance, and NASA Engineering and Quality Audit (NEQA) techniques.

XVIII. TECHNOLOGY ASSESSMENT

Ongoing assessment of needs for technology will be conducted by project management to insure that long term goals can be met.

XIX. COMMERCIALIZATION

Many of the technologies to be demonstrated have direct commercial application.

XX. REVIEWS

A. Management Reviews

Management reviews will be scheduled during the life of the project. The type and frequency of the reviews will be established according to the project unique needs and requirements. Reviews will be scheduled to keep center, program and project management informed of the current status of existing or potential problem areas. Agency management will

be informed, in advance, of the schedule and agenda of the major reviews and will be invited to participate at their discretion. Special reviews by any level of management will be scheduled when the need arises.

1. Lead Center Program Management Council (PMC) Review

The Kennedy Space Center Lead Center PMC will review the Operations and Range Technology Project annually. The reviews will cover overall status information, including schedule, change, performance, funding, interfaces coordination, and other management and technical topics. The Lead Center PMC review will also assess project progress against metrics and criteria proposed in procurement instruments.

2. Quarterly Program Review

A quarterly program review will be held to review cost, schedule, and technical issues. The location of the review will be determined on a case-by-case basis. Participants will include, as a minimum, the program managers of the ASTP and STD offices.

3. Other Reviews

Other independent reviews will be scheduled as required.

B. Technical Reviews

Each technology development effort will be reviewed at six-month increments to assess progress. Decisions for continuation, redirection, and/or cancellation will be made at that time.

XXI. TAILORING

The requirements of NASA Policy Directive (NPD) 7120.4A and NASA Procedures and Guidelines (NPG) 7120.5A apply to this program as tailored by the ASTP Program Plan.

XXII. RECORDS RETENTION

The Operations and Range Technology Project Manager will determine which project records will be retained and for how long in order to ensure a permanent record of the project and lessons learned are available to benefit future NASA projects. Governing documents will be kept in accordance with the required policies and procedures of the relevant Center.

XXIII. CHANGE LOG

EFF. DATE	STATUS	DOC. REVISION	DESCRIPTION
Dec 13, 1999	Baseline	-	Initial Issue